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A good turnout for the plenary session where the future of international, national oils and service companies was debated. Optimization proved a popular theme—with Delft presenting a novel technique for taking operators' psychology into account. Model based optimization of BP's Trinidad Field. Brownfield 'digital' revamp gets traction from Saudi Aramco. Oxy deploys 'intelligent agents.' Total now convinced of 'digital oilfield' business benefits.

The Society of Petroleum Engineers sure knows how to put on a good plenary session. The best part of a thousand of the reported 8,000 attendees showed up for the 'What's next for IOCs, NOCs* and service companies' session. Moderator Liam Mallon (ExxonMobil) noted the 'dramatic developments' of a steep rise and precipitous fall in the oil price over the last few years. These are 'trying times,' but this is a cyclical industry, energy demand will continue to grow. IOCs and NOCs need to listen to each others' views and to work together to meet energy needs.

Keith Morley (Weatherford) described the NOC/IOC relationship as 'between a rock and a hard place.' More changes will come as consumption shifts to the Asia Pacific region and as OECD demand declines. Outside of North America, E&P expenditure in set to 'explode,' and the NOCs are the new 'rule makers.' Trends towards 'resource nationalism' are in fact a good fit with the oilfield services model. The IOCs are now pushing the technological frontiers—along with the service sector innovations such as drilling with casing, solid expandables and managed pressure drilling.

Anelise Lara (Petrobras) naturally concurred with this flattering picture of the NOCs. Petrobras is planning for a $175 billion spend over the next five years and is second in R&D spend. Petrobras expects to continue to develop the technology it is using to explore and develop its ultra deepwater pre salt basins.

Jay Prior (Chevron) described rising demand in the face of a fragile economy as an 'urgent challenge.' IOC's business models are continuously evolving and there is an increasing need for collaboration. Chevron frequently partners with NOCs on projects. This is 'nowhere near a zero sum game.' It is 'in all of our interests to overcome above ground challenges.' IOCs act as efficient investors and technology providers. They offer technology transfer and act as 'catalysts' to develop host countries' human and economic resources. Chevron's partners get access to 'hard won expertise' such as that gained in California's central valley, now applied to Indonesia's heavy oil.

Mohammed Al Quahtani (Saudi Aramco) observed that although 'experts forecast more collaboration' this sometimes seemed to be 'more words than action.' Collaboration is required to find the intersection of common goals and to avoid duplication of effort that has hampered the industry in addressing its challenges. The most important of these today is how to add a required 90 million bopd by 2030—an amount equal to today's production! According to Saudi Aramco, the world holds '150 years of oil supply at current production rates.' Providing again that technological solutions are found to improve recovery. In fact new technologies dominate Aramco's scenario. Solutions are being sought through the exchange of ideas and support of R&D consortia and Universities. The service sector has proved very efficient at developing and

deploying new technologies developed in Aramco's Expec R&D center. The company has just announced a Technology Quest event to be held next month in Houston where providers can present new technologies for 'fostering and incubation' by Aramco. Regarding the thorny issue of intellectual property and commercialization, Aramco's main goal is early adoption, it promises a 'flexible attitude' on commerciality and IP sharing.

In the Q&A it emerged that not everyone was convinced of the value and roles played by the main stakeholders. The panel was asked what they valued most in collaboration. For Aramco it was long term relationships and openness. For Petrobras, a clear understanding of each player's long term objectives with technology as the driver for service companies. Petrobras sees the value in reducing risks and assessing the value of a specific technology. Clarity was also a concern for Weatherford—oilfield service companies are 'at the mercy of their shareholders' and need a solid basis for new technology development.

Trond Unneland offered a history of Chevron's involvement in seeding new technologies through its Technology Ventures (CTV) unit. New technologies are critical for oils and a 'constant infusion' is needed for success. Chevron pioneered the oil company use of venture capital in 1998 with the creation of its 'closed end' fund model. Four funds have launched over the last ten years with a total $250 million endowment. Some 200 target investments have been made, mostly in IT. Chevron likes to look in 'unlikely places' for its investment targets. Some 300-400 companies per year are scanned. Deals come in the form of unsolicited proposals (to the CTV website), technology brokers, 'friends' and from in-house proposals. Chevron has had a tremendous success with its IT investments and is now seeking to repeat the exercise in oil and gas and renewables. Projects need to impact Chevron's core business, offer a financial return, have good pilot potential and fit with the CTV portfolio and deal structure. Around 10 technologies per year have been piloted since 2000, 'value capture' through technology transfer is estimated at $100 million with an IRR that 'equates to a top tier VC.' Successes include a proprietary rod pumping system artificial lift, high performance computing (with 11 systems acquired for reservoir modeling and geophysics) and a spam filtering system that was subsequently acquired by CISCO for $830 million. Unneland has learned that perseverance is important in venture capital. It can take 3-10 years before a target is ready for a float, or goes down the tubes. Unneland stated that the prime rationale for CTV was less the ROI, more the new technology's impact on Chevron.

Gijs van Essen (Delft UT) presented a fairly technical paper on a 'null-space' approach to production optimization with a psychological twist. 'Lifecycle optimization,' as opposed to 'reactive control,' involves maximizing NPV** over the whole life of a field. Unfortunately, many optimal production strategies, even though valid, are unpalatable to production engineers. Such plans call for short term monetary loss, perhaps asking engineers to shut wells in. The idea behind van Essen's hierarchical optimization approach is to find an objective function that balances short and long term objectives. The primary objective is to maximize lifetime NPV, but secondary objectives of maximizing short term production are also considered. The technique has been demonstrated on 'toy' model reservoirs and can be implemented by alternating long and short term optimizations. Otherwise the technique is computationally a bit beyond real world reservoirs because of the huge number of variables.

Our virtual 'best paper' award goes to Anessa Ramdial (BP) for a limpid presentation of model based optimization of a gas production system in Trinidad. The Trinidad Field Optimizer (TFO), which embeds Aspen HySys and Petroleum Expert's Prosper, provides an overall representation of the gas terminal including 11 production platforms, pipelines for gas and liquids to shore and onshore to processing and

sales. Since 2005, gas prices have been flat with a big drop in 2009, meaning that today, there is a large premium on liquid delivery as long as gas deliveries are fulfilled. Gas dispatchers are using the TFO to eliminate guess work and add revenue by maximizing liquid production quickly. The enabling technology is the rapid simulator, combined with digital metering and communications. The model allows for wells, platforms or trains to be activated or turned off, matching real world situations. Daily optimization has allowed BP to deliver on its gas contracts while maximizing condensate production. 'What-if' modeling lets BP try alternative scenarios such as another supplier's failure to deliver.

A popular theme at recent ATCEs is the revamp of old fields with modern technology. Mohammed Al-Khamis described Saudi Aramco's 'i-Field' revamp of the AFK complex. AFK started producing in the 1960s and shut in the 1980s. Before the revamp the control system was entirely mechanical and there was no surveillance. The revamp included the drilling of 154 wells (most horizontal), a new central processing facility with gas processing and new production and injection facilities. AFK produces from multiple fields and multiple reservoirs per field. Surveillance of the complex crude blends proved crucial. An extensive field data network is connected via an Open Transport Network (fiber) and on to the control room. Operators now have visibility of all three fields and use multi phase meters readings to control injection. The revamp makes extensive use of OSIsoft's PI System with data replicated to Aramco's central Dhahran PI Cluster and into its Oracle E&P database. Every well has remote control and the whole field can be shutdown remotely 'with a single click.' Real time surveillance provides constantly updated isobaric maps of reservoir – where before there were two maps per year! Aramco's production/injection strategy can be adjusted continuously. Well performance is likewise optimized. The revamp has added 500kbod.

Greg Stephenson (Oxy) presented the results of trials of IntelligentAgent's optimization technology. Paradoxically, gas lift 'works' even when something is broken, e.g. following beam pump failure. Moreover, data overload and a lack of domain expertise means that such 'non critical' failures don't get fixed. Oxy has been trialing an artificial intelligence approach, using 'intelligent agents,' that 'observe and act on their environment.' The 'robust' technology was originally developed for the defense and intelligence industries.

The agent monitors wells in real time and can be trained to identify abnormal operating conditions such as surges and recommend remedial action. An 'over defined' knowledge base holds a multiplicity of known conditions and works even with imperfect data. Some 60 different conditions have been defined and are monitored with 15 attributes of flow rate, valve state, etc. An open architecture integrates many IT environments and multiple commercial nodal analysis platforms. A system dashboard provides drill down for an in depth look at why a particular diagnosis was made. The system has undergone extensive testing and field trials on a mature Western US water flood with around a thousand instrumented and gas lift wells. Oxy now analyzes wells in record time, has improved its production management workflow and now spends less time on data mining. IntelligentAgent and Weatherford co-authored the paper.

Optimization was also the theme of the special 'Digital Energy' session where James Griffith (Shell) showed how development planning on an Albertan heavy-oil project benefitted from Halliburton's DecisionSpace and Compass tools for analyzing fixed and variable constraints on well locations. Subsurface and well construction parameters were tuned by running multiple scenarios and the field's NPV raised by 10% ($250M) over the base case. The software took input of well targets, geometry and slot templates, and optimized for surface locations and well trajectories, injector vs. producer allocation and geologic targets hit. Results were turned over to a well construction team to implement in the field.

Carol Piovesan of APO Offshore described an intelligent platform solution for taking predictive analytics techniques that have been successfully benchmarked in downhole and production projects and applying them to surface equipment on offshore rigs. The system includes a “Meta-SCADA” data aggregator on the rig, neural networking and self-organizing maps and industry standard dashboards for delivery of Key Performance Indicators. The solution would allow a limited pool of globally dispersed subject matter experts to reduce downtime by as much as 20% by using data streams that today dead-end on the rig floor but could be transmitted over existing satellite links.

Speaking at the otherwise uninspired IT Section session, Total’s Michel-Jean Guillé recounted how Total initially took the ‘digital oilfield’ concept to be a ‘consulting buzz.’ Total is now more convinced of the business benefits. Total has tested digital oilfield concepts on its Sendji field (Congo) with continuous monitoring, KPIs of plant performance to detect sub optimal behavior and gas lift optimization on 54 wells. Real time visualization over the web led to a 2-4% increase in production and reduced visits to the field. Real time geosteering means that Total now works in a ‘collaboration loop’ with deviations from the geological sparking off updated velocities, geology and adjustment to the well targets. The digital oilfield concept is now considered proven – but less as a ‘big bang’ more of a continuous improvement process. Again good telecoms are a pre requisite for a successful digitization project. This can be hard in Africa. Total advocates the use of ‘adapters,’ IT standards, telecom/EAI tools and middleware. The company is also a strong promoter of newer standards such as PRODML and WITSML.

* *International, National Oil Companies.*

** *Net present value.*